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Monthly Performance Report

RHRU, CLEMSON

APRIL 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT
RHRU, CLEMSON
APRIL 1979

I. SITE DESCRIPTION

The Rural Housing Research Unit (RHRU) of the United States Department of Agriculture (USDA) Science and Education Administration (SEA) solar energy site is an instrumented, combination greenhouse and residence at Clemson University, and is sponsored by the Appalachian Regional Commission and the South Carolina Agricultural Experimentation Station. The two-story house uses both active and passive solar components for space heating, space cooling, and domestic hot water heating. This site is operated by the South Carolina Agriculture Experimentation Station at Clemson, South Carolina. The active system has 381 square feet of flat-plate collectors built by the USDA. The collector array faces due south and is tilted at an angle of 60 degrees from the horizontal. Air is used as the transfer medium for delivering solar energy from the collector array to storage. The air entering the collectors may be preheated by routing it through the greenhouse, which has a projected area of 352 square feet in the plane of the collectors.

The energy is stored in 1,161 cubic feet of rock located in a storage bin beneath the house. Space heating is accomplished by circulating warmed air from the collector, or the rock storage bin, through the conditioned spaces. Space cooling is provided by circulating cooled air from outside, or from the rock storage bin, through the conditioned spaces. Auxiliary heating is furnished by 20-kilowatt electric heat strips, and auxiliary cooling is provided by a 2.5-ton air conditioner. The heat strips and the air conditioner evaporator coils are located in the air-handler unit supply plenum. Domestic hot water (DHW) is preheated by circulating city water in a 42-gallon preheat tank through an air-to-liquid heat exchanger located in the collector outlet plenum. Auxiliary hot water heating is furnished by a 4.5-kilowatt electrical element in a 42-gallon hot water tank.

The system, shown schematically in Figure 1 and pictorially in Figure 2, has three winter modes of operation, four summer modes, and a domestic hot water mode.

A. Winter Operation

Mode 1 - Storage-to-Space Heating: Warm air is transferred from the rock thermal storage by the air-handler unit to the house. Return air from the house may be recycled through the greenhouse at night under the control of manual dampers. This maintains the minimum greenhouse temperature at approximately 50°F. When the air temperature of the rock thermal storage is insufficient to satisfy the space heating demand, auxiliary energy is supplied by the electrical heat strips.

Mode 2 - Collector-to-Space Heating: During periods of adequate solar insolation, space heating is supplied to the conditioned space by drawing warm air directly from the collector outlet plenum. The return air is recycled through the solar collector for reheating and redistribution.

Mode 3 - Collector-to-Storage: During periods of adequate insolation when there is no space heating demand, warm air is routed from the collector outlet through rock thermal storage and back to the collector. To utilize the energy collected by the greenhouse and to avoid overheating, air returning to the collector may be circulated through the greenhouse.

B. Summer Operation

Mode 1 - Purge: During the summer, the rock thermal storage is used for cooling. The heat energy built up during the day is purged, generally at night, by circulating cool outside air through the rock thermal storage. This air bypasses the greenhouse and is vented through the solar collector to the outside.

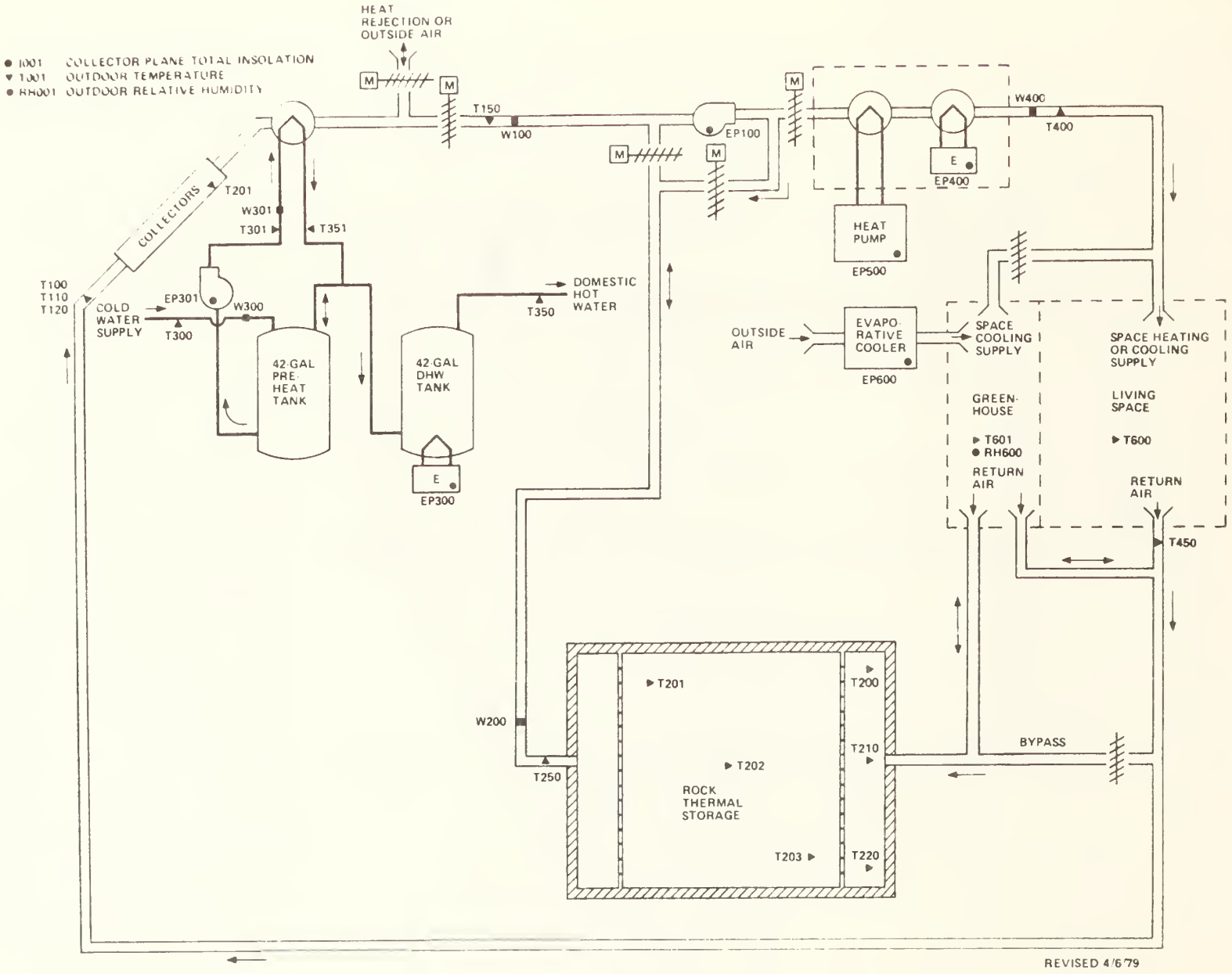

Figure 1. RHRU CLEMSON SOLAR ENERGY SYSTEM SCHEMATIC

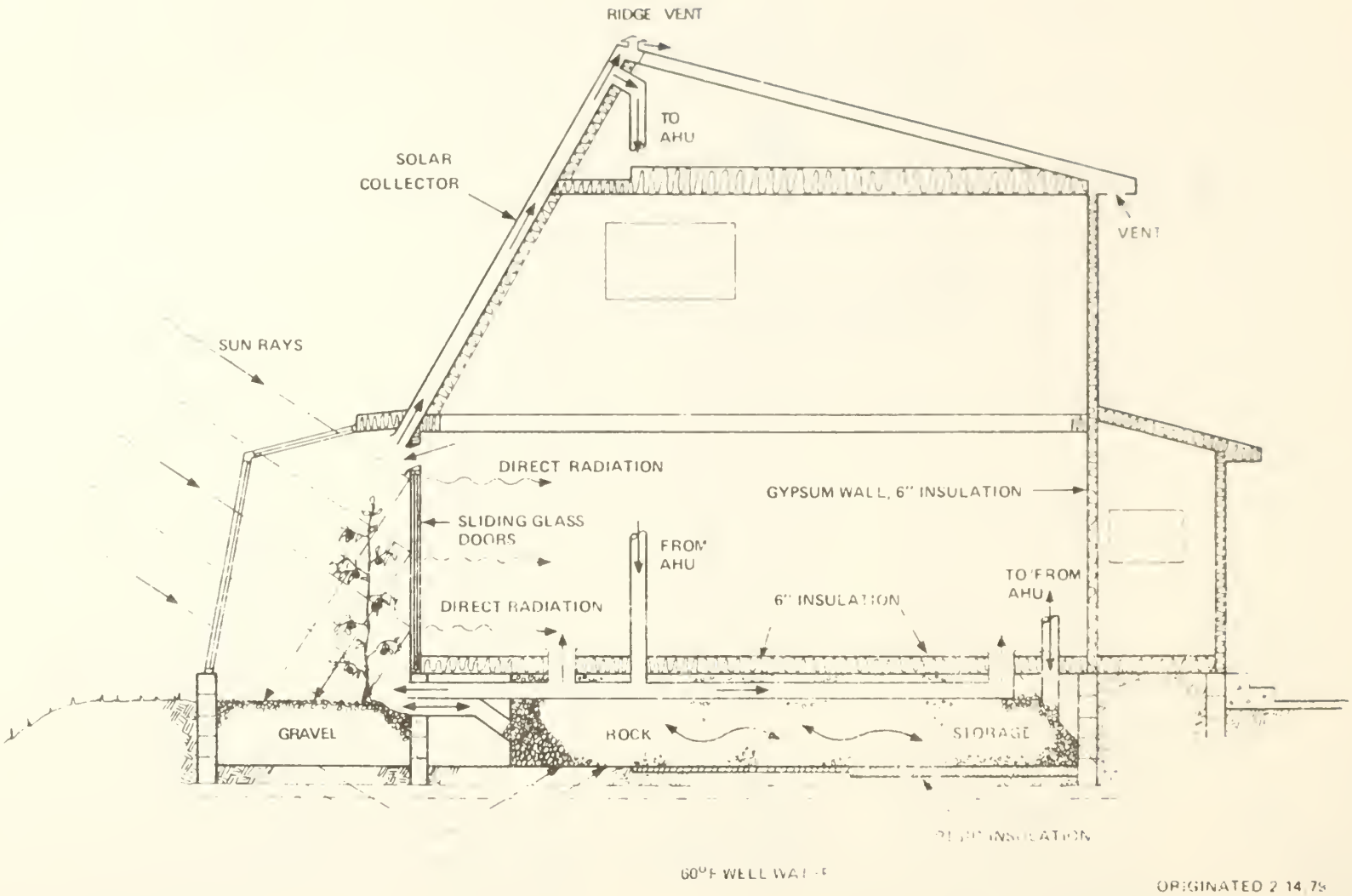

Figure 2 RHRU CLEMSON SOLAR SYSTEM PICTORAL

Mode 2 - Storage-to-Space Cooling: Air from the conditioned space is circulated through the rock storage which was cooled by the previous purge mode. Additional cooling is supplied by the auxiliary evaporator coils located in the air-handler unit supply plenum.

Mode 3 - Outside Air-to-Space Cooling: Cool air is drawn from outside and delivered to the house. The return air is circulated through the solar collector and vented to the outside.

Mode 4 - Greenhouse Venting: Solar energy absorbed by the greenhouse and collector array is vented to the outside.

C. Domestic Hot Water Operation

The DHW preheat mode is used in both winter and summer. Water from the preheat tank circulates through the air-to-water heat exchanger. Hot water flow through the heat exchanger begins when the temperature at the heat exchanger is 3°F above the preheat tank temperature, and reaches maximum flow rate when the temperature difference is 23°F. Flow stops when the temperature difference decreases below 3°F. The proportional control device ensures that the flow rate is proportional to the temperature difference. Whenever the temperature at the heat exchanger decreases below 35°F, water from the preheat tank circulates through the air-to-water heat exchanger to protect the system from freezing.

II. PERFORMANCE EVALUATION

The system performance evaluations discussed in this section are based primarily on the analysis of the data presented in the attached computer-generated monthly report. This attached report consists of daily site thermal and energy values for each subsystem, plus environmental data. The performance factors discussed in this report are based upon the definitions contained in NBSIR 76-1137, Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program.

A. Introduction

All solar energy subsystems at the site were operational throughout the month of April. These subsystems supplied 41 percent of the 0.8 million Btu domestic hot water heating load. There was no measured space heating load. Auxiliary energy contributed an additional 0.7 million Btu for hot water heating. The conditioned space was maintained at approximately 76°F. On the average, 56 gallons of hot water were used daily.

B. Weather

The average daily insolation measured in the plane of the collector array was 1,335 Btu/ft^2-day, and the long-term F-Chart predicted value was 1,590 Btu/ft^2-day. The average daily temperatures ranged from 51°F to 68°F, averaging 60°F for the month. The long-term predicted value was 61°F, taken at the Greenville-Spartanburg Airport.

C. System Thermal Performance

Collector - Of the 29.4 million Btu incident on the plane of the collectors and the projected plane of the greenhouse, 19.9 million Btu were available during the time of actual collection operation, and 3.9 million Btu were collected. The flat-plate array collected 3.1 million Btu and the greenhouse collected 0.8 million Btu. The efficiency of the combined flat-plate and greenhouse operation was 13 percent.

Of the 3.9 million Btu of solar energy collected, 2.8 million Btu were delivered to storage, 0.3 million Btu were transferred to the domestic hot water (DHW) subsystem, and 0.8 million Btu could not be measured and are considered losses.

Storage - No energy was removed from storage for space heating. Storage energy decreased 0.7 million Btu during April resulting in a total storage loss of 3.5 million Btu.

Space Heat Load - No space heating was supplied to the house or greenhouse in April. The solar energy system was placed in the summer operating mode on April 27.

Hot Water Load - The measured 0.8 million Btu domestic hot water load was met by 0.3 million Btu of solar energy, and 0.7 million Btu of auxiliary energy. The solar fraction of the load, based on solar energy contributed to the tank energy level supplying the load, was 41 percent. The hot water subsystem efficiency for the month, assuming no net monthly change in the energy levels of the tanks, was 80 percent. The combined solar and auxiliary energy raised the supply water temperature an average of 60°F.

On April 6, the 42-gallon DHW tank was combined with the preheat tank and a 30-gallon DHW tank was added to the system. The new configuration is shown in Figure 3. Prior to April 6, the DHW solar fraction was 32 percent and the solar system conversion efficiency was 1.0 percent. Following reconfiguration, these performance factors increased to 43 percent and 1.1 percent, respectively.

D. Observations

Storage temperature decreased from 88°F to 57°F throughout the last few days of April, as the system was switched over from winter to summer operation. The purge mode is indicated by the negative daily values of energy added to storage and to the greenhouse. Energy was removed from the greenhouse on April 1-27 during solar collection, and some energy was added to the greenhouse while purging the greenhouse on April 28-30.

E. Energy Savings

The use of the active solar energy components in April provided a total electrical energy savings of 0.2 million Btu. This is equivalent to the additional energy required to supply the domestic hot water needs if the residence relied solely on conventional electric power.

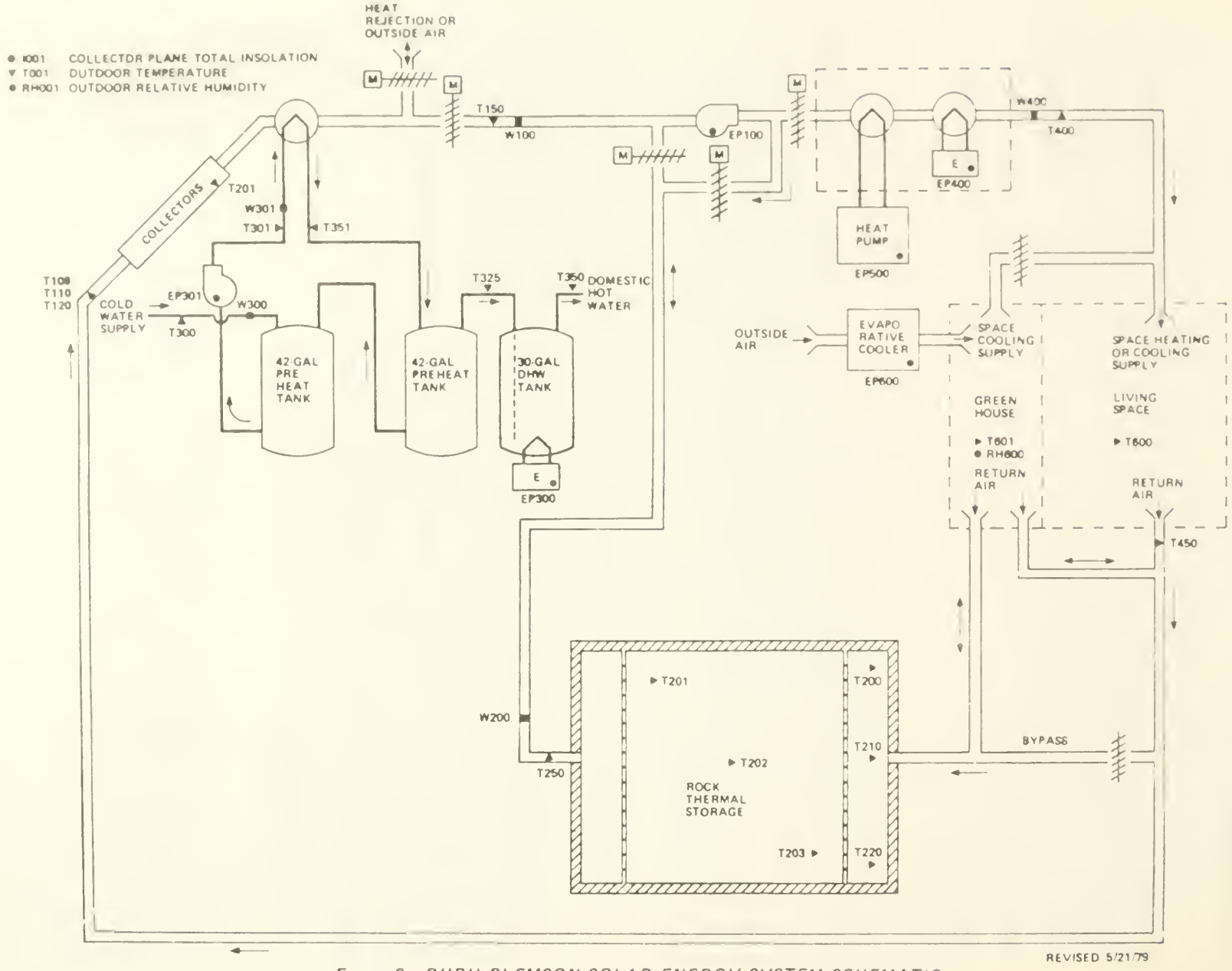

Figure 3. RHRU CLEMSON SOLAR ENERGY SYSTEM SCHEMATIC

III. ACTION STATUS

The solar energy system and the instrumentation are currently operating with no known problems.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: RHRL CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2066-79/04
REPORT PERIOD: APRIL,1979

SITE/SYSTEM DESCRIPTION:
THE RHRL CLEMSON SOLAR ENERGY SYSTEM PROVIDES SPACE HEATING AND DOMESTIC HOT WATER PREHEATING. AIR IS USED AS THE COLLECTION MEDIUM AND TRANSFER MEDIUM FOR THE SPACE HEATING SYSTEM. COLLECTED ENERGY IS DIRECTED EITHER TO THE LOAD OR TO A ROCK BED UNIT FOR STORAGE. ELECTRIC RESISTANCE ELEMENTS PROVIDE AUXILIARY HEAT.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	29.358 MILLION BTU
	40036 BTU/SQ.FT.
COLLECTED SOLAR ENERGY	3.918 MILLION BTU
	5343 BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	60 DEGREES F
AVERAGE BUILDING TEMPERATURE	76 DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.01
ECSS OPERATING ENERGY	0.183 MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.212 MILLION BTU
TOTAL ENERGY CONSUMED	4.872 MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	0.849	0.000	N.A.	0.849 MILLION BTU
SOLAR FRACTION	41	0	N.A.	41 PERCENT
SOLAR ENERGY USED	0.329	0.000	N.A.	0.386 MILLION BTU
OPERATING ENERGY	0.029	0.000	N.A.	0.212 MILLION BTU
AUX. THERMAL ENERGY	0.742	0.000	N.A.	0.742 MILLION BTU
AUX. ELECTRIC FUEL	0.742	0.000	N.A.	0.742 MILLION BTU
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
ELECTRICAL SAVINGS	0.356	0.000	N.A.	0.173 MILLION BTU
FOSSIL SAVINGS	N.A.	N.A.	N.A.	N.A. MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.267

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978. SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: RHRU CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2086-79/04
REPORT PERIOD: APRIL,1979

SITE/SYSTEM DESCRIPTION:
THE RHRU CLEMSON SOLAR ENERGY SYSTEM PROVIDES SPACE HEATING AND DOMESTIC HOT WATER PREHEATING. AIR IS USED AS THE COLLECTION MEDIUM AND TRANSFER MEDIUM FOR THE SPACE HEATING SYSTEM. COLLECTED ENERGY IS DIRECTED EITHER TO THE LOAD OR TO A ROCK BED UNIT FOR STORAGE. ELECTRIC RESISTANCE ELEMENTS PROVIDE AUXILIARY HEAT.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	30.973	GIGA JOULES
	454645	KJ/SQ.M.
COLLECTED SOLAR ENERGY	4.134	GIGA JOULES
	60678	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	16	DEGREES C
AVERAGE BUILDING TEMPERATURE	24	DEGREES C
DOSS SOLAR CONVERSION EFFICIENCY	0.01	
DOSS OPERATING ENERGY	0.193	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.224	GIGA JOULES
TOTAL ENERGY CONSUMED	5.140	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	0.896	0.000	N.A.	0.896 GIGA JOULES
SOLAR FRACTION	41	0	N.A.	41 PERCENT
SOLAR ENERGY USED	0.383	0.000	N.A.	0.407 GIGA JOULES
OPERATING ENERGY	0.031	0.000	N.A.	0.224 GIGA JOULES
AUX. THERMAL ENG	0.783	0.000	N.A.	0.783 GIGA JOULES
AUX. ELECTRIC FUEL	0.783	0.000	N.A.	0.783 GIGA JOULES
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.	N.A. GIGA JOULES
ELECTRICAL SAVINGS	0.376	0.000	N.A.	0.183 GIGA JOULES
FOSSIL SAVINGS	N.A.	N.A.	N.A.	N.A. GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.267

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: RFRU CLEMSON - CLEMSON,SOUTH CAROLINA SCLAR/2086-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	1.167	66	0.010	N	0.007	N	0.010
2	0.192	63	0.003	O	0.000	O	0.066
3	0.074	58	0.000	T	0.000	T	0.102
4	0.111	53	0.001		0.000		0.026
5	1.536	56	0.017	A	0.009	A	0.010
6	1.458	58	0.006	P	0.006	P	0.010
7	1.461	60	0.019	P	0.008	P	0.010
8	0.502	55	0.006	L	0.000	L	0.042
9	1.504	57	0.015	I	0.008	I	0.003
10	1.451	51	0.017	C	0.008	C	0.017
11	0.200	57	0.003	A	0.000	A	0.019
12	0.211	61	0.004	E	0.000	E	0.047
13	0.043	59	0.000	L	0.000	L	0.135
14	1.394	61	0.018	E	0.008	E	0.009
15	1.463	60	0.018		0.008		0.014
16	1.457	62	0.015		0.008		0.013
17	1.429	60	0.018		0.008		0.014
18	1.429	59	0.015		0.008		0.018
19	1.419	58	0.017		0.007		0.010
20	1.375	63	0.012		0.007		0.019
21	1.207	65	0.016		0.006		0.017
22	1.146	66	0.014		0.006		0.013
23	0.591	68	0.012		0.001		0.026
24	0.580	68	0.009		0.001		0.020
25	0.144	61	0.000		0.000		0.044
26	0.468	64	0.010		0.001		0.021
27	1.609	66	0.014		0.017		0.001
28	1.381	58	0.011		0.023		0.004
29	1.041	52	0.012		0.018		0.003
30	1.314	58	0.015		0.010		0.009
SUM	29.358	-	0.328	N.A.	0.183	N.A.	-
AVG	0.979	60	0.011	N.A.	0.006	N.A.	0.013
NBS ID	0001	N113			0102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: RHRU CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2086-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	1.167	0.899	0.228	75	0.195
2	0.192	0.000	0.003	67	0.013
3	0.074	0.000	0.000	60	0.007
4	0.111	0.000	0.001	53	0.006
5	1.536	1.341	0.342	65	0.223
6	1.458	1.214	0.260	68	0.178
7	1.461	1.248	0.337	71	0.231
8	0.502	0.024	0.013	65	0.026
9	1.504	1.249	0.273	64	0.182
10	1.451	1.173	0.298	63	0.205
11	0.200	0.000	0.003	62	0.014
12	0.211	0.000	0.004	63	0.021
13	0.043	0.000	0.000	59	0.000
14	1.394	1.283	0.346	*	0.248
15	1.463	1.279	0.326	72	0.223
16	1.457	1.249	0.320	71	0.220
17	1.429	1.192	0.312	71	0.219
18	1.429	1.191	0.324	72	0.227
19	1.419	1.073	0.283	71	0.200
20	1.375	1.099	0.293	76	0.213
21	1.207	0.922	0.246	77	0.204
22	1.146	0.777	0.221	76	0.193
23	0.591	0.095	0.040	76	0.067
24	0.580	0.141	0.045	75	0.077
25	0.144	0.000	0.000	*	0.003
26	0.468	0.128	0.041	69	0.087
27	1.609	1.414	0.156	73	0.097
28	1.381	0.756	-0.300	68	-0.217
29	1.041	0.117	-0.351	62	-0.338
30	1.314	0.003	-0.147	71	-0.112
SUM	29.358	19.866	3.918	-	-
AVG	0.979	0.662	0.131	68	0.133
RESID	0001		0100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: RRRU CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2066-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.166	0.000	0.033	92	0.197
2	0.000	0.000	-0.076	91	1.000
3	0.000	0.000	-0.072	87	1.000
4	0.000	0.000	-0.061	84	1.000
5	0.250	0.000	0.122	85	0.487
6	0.094	0.000	0.057	90	0.604
7	0.245	0.000	0.067	92	0.274
8	0.006	0.000	-0.119	92	-21.576
9	0.193	0.000	0.056	90	0.289
10	0.211	0.000	0.038	92	0.179
11	0.000	0.000	-0.081	91	1.000
12	0.000	0.000	-0.069	87	1.000
13	0.000	0.000	-0.059	85	1.000
14	0.251	0.000	0.125	86	0.500
15	0.235	0.000	0.066	90	0.281
16	0.230	0.000	0.079	94	0.343
17	0.227	0.000	0.028	96	0.125
18	0.239	0.000	0.028	98	0.119
19	0.206	0.000	-0.006	99	-0.030
20	0.216	0.000	0.022	99	0.099
21	0.179	0.000	-0.004	99	-0.024
22	0.161	0.000	-0.016	99	-0.102
23	0.020	0.000	-0.071	97	-3.531
24	0.025	0.000	-0.065	94	-2.596
25	0.000	0.000	-0.067	90	1.000
26	0.022	0.000	-0.046	86	-2.101
27	0.139	0.000	-0.058	88	-0.418
28	-0.195	0.000	-0.330	77	1.697
29	-0.237	0.000	-0.171	62	0.721
30	-0.101	0.000	-0.063	57	0.626
SUM	2.782	0.000	-0.714	-	-
AVG	0.093	0.000	-0.024	89	-0.257
RES ID	G200	G201	G202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: RHRU CLEMSON - CLEMSON,SOUTH CAROLINA
REPORT PERIOD: APRIL,1979

SOLAR/2086-79/04

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.028	42	0.010	0.001	0.027	0.027	N	0.011	N	63	132	48
2	0.035	32	0.003	0.000	0.040	0.040	O	0.013	O	61	129	60
3	0.038	22	0.000	0.000	0.038	0.038	T	0.008	T	64	128	70
4	0.017	18	0.001	0.000	0.027	0.027		0.003		60	129	29
5	0.033	46	0.017	0.001	0.028	0.028	A	0.014	A	62	127	63
6	0.038	24	0.006	0.000	0.041	0.041	P	0.014	P	65	96	108
7	0.018	58	0.019	0.001	0.011	0.011	P	0.013	P	65	106	48
8	0.039	51	0.006	0.001	0.024	0.024	L	0.020	L	62	109	104
9	0.012	43	0.015	0.001	0.012	0.012	I	0.003	I	61	111	31
10	0.038	51	0.017	0.001	0.021	0.021	C	0.024	C	63	107	113
11	0.008	62	0.003	0.000	0.008	0.008	A	0.003	A	62	111	19
12	0.030	37	0.004	0.000	0.035	0.035	B	0.009	B	59	109	61
13	0.029	20	0.000	0.000	0.032	0.032	L	0.006	L	59	136	49
14	0.020	45	0.018	0.001	0.017	0.017	E	0.011	E	63	135	34
15	0.039	56	0.018	0.001	0.027	0.027		0.019		63	132	61
16	0.037	26	0.015	0.001	0.027	0.027		0.017		66	135	67
17	0.039	37	0.018	0.001	0.027	0.027		0.018		69	129	67
18	0.038	63	0.019	0.001	0.019	0.019		0.025		68	125	63
19	0.029	43	0.017	0.001	0.024	0.024		0.012		66	126	58
20	0.041	70	0.012	0.001	0.024	0.024		0.025		69	130	70
21	0.036	49	0.016	0.001	0.023	0.023		0.019		63	137	61
22	0.029	46	0.014	0.001	0.022	0.022		0.014		67	137	46
23	0.033	54	0.012	0.001	0.026	0.026		0.014		65	142	70
24	0.032	37	0.009	0.001	0.028	0.028		0.011		64	138	55
25	0.019	40	0.000	0.000	0.024	0.024		0.006		66	128	44
26	0.034	35	0.010	0.001	0.033	0.033		0.009		66	121	79
27	0.005	23	0.014	0.001	0.010	0.010		0.000		72	134	9
28	0.009	35	0.011	0.001	0.015	0.015		0.004		79	130	19
29	0.007	28	0.012	0.001	0.012	0.012		0.002		66	126	13
30	0.041	25	0.015	0.002	0.039	0.039		0.010		67	132	68
SUM	0.849	-	0.325	0.029	0.742	0.742	N.A.	0.356	N.A.	-	-	1685
AVG	0.028	41	0.011	0.001	0.025	0.025	N.A.	0.012	N.A.	65	125	56
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: RHRU CLEMSON - CLEMSON,SOUTH CAROLINA
REPORT PERIOD: APRIL,1979

SOLAR/2086-79/04

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	CREP ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.000	0	0.000	0.000	0.000	0.000	N	0.000	N	77	68
2	0.000	0	0.000	0.000	0.000	0.000	O	0.000	O	77	63
3	0.000	0	0.000	0.000	0.000	0.000	T	0.000	T	76	58
4	0.000	0	0.000	0.000	0.000	0.000		0.000		73	53
5	0.000	0	0.000	0.000	0.000	0.000	A	0.000	A	75	56
6	0.000	0	0.000	0.000	0.000	0.000	P	0.000	P	75	58
7	0.000	0	0.000	0.000	0.000	0.000	P	0.000	P	77	60
8	0.000	0	0.000	0.000	0.000	0.000	L	0.000	L	75	55
9	0.000	0	0.000	0.000	0.000	0.000	I	0.000	I	75	57
10	0.000	0	0.000	0.000	0.000	0.000	C	0.000	C	75	51
11	0.000	0	0.000	0.000	0.000	0.000	A	0.000	A	73	57
12	0.000	0	0.000	0.000	0.000	0.000	B	0.000	B	72	61
13	0.000	0	0.000	0.000	0.000	0.000	L	0.000	L	74	59
14	0.000	0	0.000	0.000	0.000	0.000	E	0.000	E	76	61
15	0.000	0	0.000	0.000	0.000	0.000		0.000		76	60
16	0.000	0	0.000	0.000	0.000	0.000		0.000		77	62
17	0.000	0	0.000	0.000	0.000	0.000		0.000		75	60
18	0.000	0	0.000	0.000	0.000	0.000		0.000		78	59
19	0.000	0	0.000	0.000	0.000	0.000		0.000		79	58
20	0.000	0	0.000	0.000	0.000	0.000		0.000		81	63
21	0.000	0	0.000	0.000	0.000	0.000		0.000		81	65
22	0.000	0	0.000	0.000	0.000	0.000		0.000		78	66
23	0.000	0	0.000	0.000	0.000	0.000		0.000		78	68
24	0.000	0	0.000	0.000	0.000	0.000		0.000		77	68
25	0.000	0	0.000	0.000	0.000	0.000		0.000		73	61
26	0.000	0	0.000	0.000	0.000	0.000		0.000		75	64
27	0.000	0	0.000	0.000	0.000	0.000		0.000		77	66
28	0.000	0	0.000	0.000	0.000	0.000		0.000		73	58
29	0.000	0	0.000	0.000	0.000	0.000		0.000		70	52
30	0.000	0	0.000	0.000	0.000	0.000		0.000		70	58
SUM	0.000	-	0.000	0.000	0.000	0.000	N.A.	0.000	N.A.	-	-
AVG	0.000	0	0.000	0.000	0.000	0.000	N.A.	0.000	N.A.	76	60
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
0 DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: HHRC CLEMSON - CLEMSON, SOUTH CAROLINA
REPORT PERIOD: APRIL, 1979

SOLAR/208-79/04

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	1591	N	68	75	72	N	N
2	261	C	63	67	87	C	C
3	101	T	58	60	100	T	T
4	152		52	53	100		
5	2095	A	56	65	58	A	A
6	1989	P	58	68	48	P	P
7	1992	P	60	71	51	P	P
8	684	L	55	65	67	L	L
9	2051	I	57	64	73	I	I
10	1979	C	51	63	71	C	C
11	273	A	57	62	83	A	A
12	287	B	61	63	99	B	B
13	58	L	59	59	100	L	L
14	1902	E	61	*	69	E	E
15	1996		60	72	54		
16	1987		62	71	35		
17	1948		60	71	48		
18	1949		59	72	53		
19	1935		58	71	55		
20	1876		63	76	59		
21	1645		65	77	68		
22	1963		66	76	75		
23	806		68	76	78		
24	791		68	75	77		
25	197		61	*	98		
26	638		64	69	96		
27	2195		66	73	70		
28	1884		58	68	60		
29	1420		52	62	69		
30	1792		58	71	67		
SUM	40036	N.A.	-	-	-	-	-
AVG	1334	N.A.	60	68	72	N.A.	N.A.
NBS ID	QC01		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
GREENHOUSE PERFORMANCE

SITE: RFRL CLEMSON - CLEMSON, SOUTH CAROLINA SOLAR/2086-79/04
REPORT PERIOD: APRIL, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	ENERGY FROM GREENHOUSE MILLION BTU	ENERGY TO GREENHOUSE MILLION BTU	GREENHOUSE TEMP DEG F	GREENHOUSE RELATIVE HUMIDITY PERCENT	GREENHOUSE & RESIDENCE ELECTRIC LOAD MILLION BTU
1	0.560	0.048	0.000	76	68.3	0.074
2	0.092	0.000	0.000	70	76.8	0.078
3	0.036	0.000	0.000	65	87.7	0.076
4	0.053	0.000	0.000	62	87.3	0.065
5	0.737	0.073	0.000	70	68.6	0.085
6	0.700	0.020	0.000	70	62.1	0.097
7	0.701	0.067	0.000	70	61.7	0.068
8	0.241	0.002	0.000	65	72.0	0.073
9	0.722	0.056	0.000	70	68.5	0.061
10	0.697	0.058	0.000	67	66.4	0.071
11	0.096	0.000	0.000	65	73.9	0.040
12	0.101	0.000	0.000	68	81.3	0.070
13	0.020	0.000	0.000	64	88.6	0.065
14	0.669	0.078	0.000	71	71.4	0.067
15	0.702	0.070	0.000	71	63.0	0.079
16	0.699	0.066	0.000	72	60.3	0.075
17	0.686	0.064	0.000	71	65.0	0.079
18	0.686	0.069	0.000	70	65.9	0.064
19	0.681	0.060	0.000	70	65.0	0.071
20	0.660	0.060	0.000	72	67.6	0.078
21	0.579	0.054	0.000	73	70.7	0.071
22	0.550	0.046	0.000	75	68.8	0.067
23	0.284	0.006	0.000	77	63.7	0.070
24	0.279	0.010	0.000	76	64.9	0.063
25	0.069	0.000	0.000	69	73.0	0.061
26	0.225	0.006	0.000	74	75.5	0.072
27	0.773	0.054	0.000	76	65.4	0.068
28	0.663	-0.040	0.000	74	52.1	0.087
29	0.500	-0.062	0.000	72	51.6	0.081
30	0.631	-0.020	0.000	71	61.8	0.097
SUM	14.093	0.847	0.000	-	-	2.174
AVG	0.470	0.028	0.000	70	68.966	0.072

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
FLAT PLATE COLLECTOR ARRAY PERFORMANCE

SITE: RHRL CLEMSON - CLEMSON,SOUTH CAROLINA
SOLAR/2086-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F
1	0.607	0.467	0.180	75
2	0.100	0.000	0.003	67
3	0.039	0.000	0.000	60
4	0.058	0.000	0.001	53
5	0.755	0.697	0.269	65
6	0.758	0.631	0.240	66
7	0.755	0.649	0.271	71
8	0.261	0.012	0.011	65
9	0.782	0.650	0.218	64
10	0.755	0.610	0.240	63
11	0.104	0.000	0.003	62
12	0.110	0.000	0.004	63
13	0.022	0.000	0.000	59
14	0.725	0.667	0.268	*
15	0.761	0.665	0.256	72
16	0.758	0.649	0.254	71
17	0.743	0.620	0.248	71
18	0.743	0.620	0.255	72
19	0.738	0.558	0.223	71
20	0.715	0.571	0.233	76
21	0.627	0.479	0.192	77
22	0.596	0.404	0.175	76
23	0.307	0.049	0.034	76
24	0.302	0.073	0.035	75
25	0.075	0.000	0.000	*
26	0.243	0.067	0.032	69
27	0.837	0.735	0.102	73
28	0.718	0.393	-0.259	68
29	0.541	0.061	-0.289	62
30	0.683	0.002	-0.126	71
SUM	15.266	10.330	3.071	-
AVG	0.509	0.344	0.102	68
RESID	0001		0100	

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
EXTREMA

SITE: RFRL CLEMSON - CLEMSON,SOUTH CAROLINA SOLAR/2086-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	GREENHOUSE MAXIMUM TEMP DEG F	GREENHOUSE MINIMUM TEMP DEG F	GREENHOUSE MAXIMUM RELATIVE HUMIDITY PERCENT	GREENHOUSE MINIMUM RELATIVE HUMIDITY PERCENT	COLLECTOR OUTLET MAXIMUM TEMP DEG F
1	91	63	86.7	43.4	121
2	82	64	87.8	63.3	84
3	70	61	90.5	82.8	79
4	71	58	91.2	78.0	76
5	91	50	88.6	44.6	128
6	90	51	81.1	35.6	126
7	90	49	79.7	41.3	129
8	87	52	85.2	42.2	102
9	88	56	89.4	45.3	120
10	87	46	84.7	44.5	124
11	78	55	84.6	61.0	84
12	81	60	87.2	65.3	81
13	67	55	90.7	86.4	75
14	89	53	92.2	49.7	129
15	89	51	87.0	38.0	125
16	90	54	75.7	43.5	129
17	89	51	83.4	43.8	128
18	90	48	84.2	45.5	131
19	89	49	82.8	42.1	127
20	89	53	85.6	46.8	129
21	89	55	86.1	51.2	123
22	91	58	87.4	46.1	125
23	90	68	70.7	49.9	114
24	90	66	79.1	49.7	113
25	76	66	79.6	68.7	81
26	90	65	87.9	59.9	116
27	89	62	90.5	46.8	126
28	87	64	65.8	34.4	71
29	87	60	60.3	38.7	72
30	88	57	74.1	48.3	79
SUM	-	-	-	-	-
AVG	86	57	83.3	51.2	108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

*U.S. GOVERNMENT PRINTING OFFICE: 1979-640-189/4172. Region 4.

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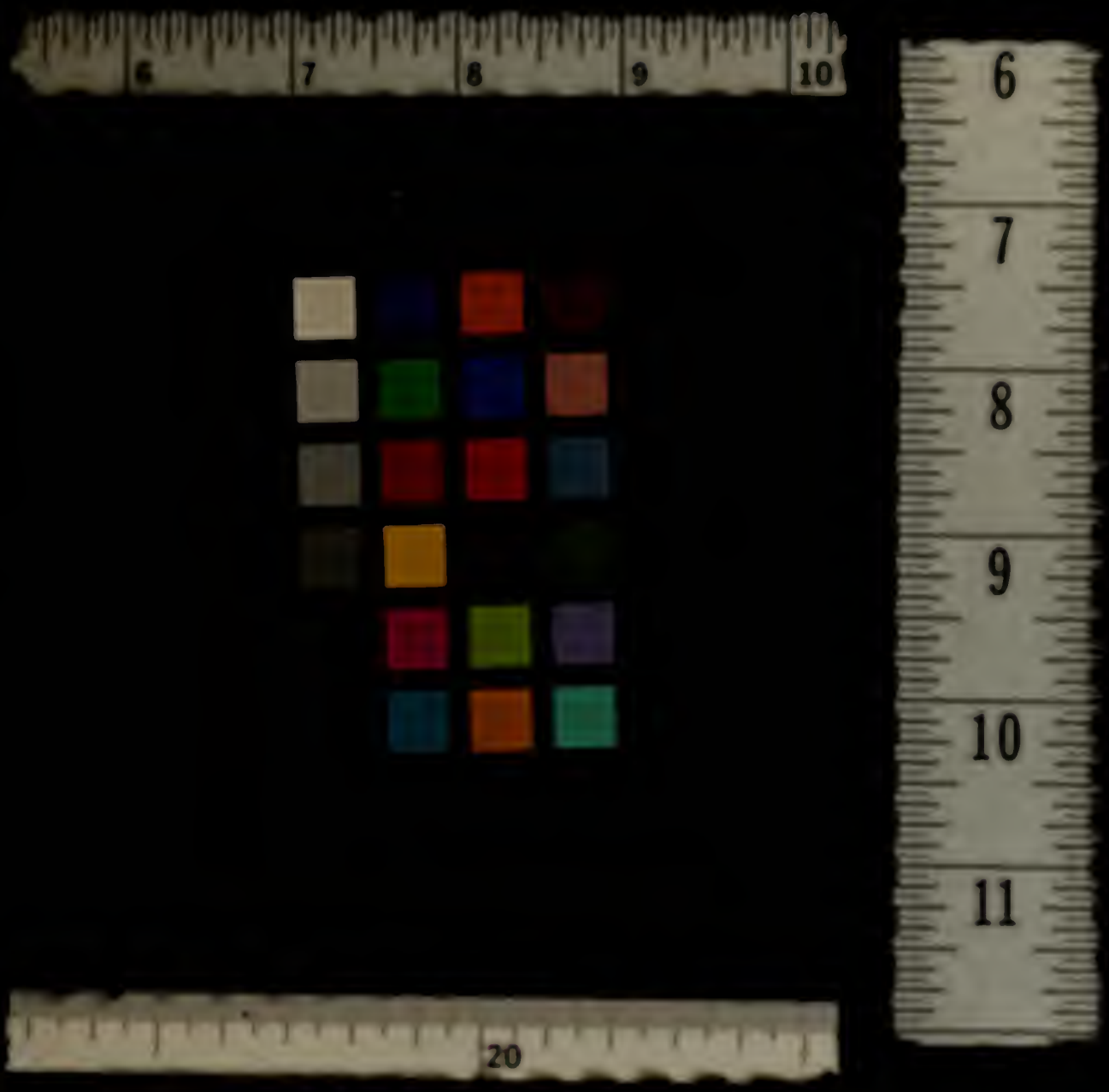
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